Brief

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Assessment of Multiple Left-Turn Phasing Strategies

Research Development and Technology

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Introduction

Left-turn movements at an intersection affect the capacity of that intersection. As the left-turning volume at an intersection continues to grow, the green time required to meet the left-turn demand increases. This, in turn results in longer cycle lengths. Also with the increase in the left-turn volume, the queues lengthen resulting in greater storage length requirements. The combinations of these effects tend to increase delay at the intersection and lower the level of service. Installation of multiple left-turn lanes (dual and triple) can result in the reduction of vehicle queue lengths, delays and left-turn storage length.

Dual and triple left-turn lanes require less green time compared to single left-turn lanes to meet the left-turning vehicle demand. This saving in the green time can be allocated to the other operations at the intersection thus resulting in the increase of intersection capacity. "Left-turn movement capacity can be increased by an average of 80% during peak hours when a dual left-turn lane is installed on a high volume left-turn approach". The installation of triple left-turn lanes result in similar advantages like increase in the intersection capacity, reduction in the minimum green time given to the left-turn movement so that it can be assigned to other intersection movements.

In Missouri, multiple left-turns are gaining popularity. However, the installation of these multiple left-turns raises questions for which the Missouri Department of Transportation (MoDOT) has not yet developed answers. Specifically, MoDOT seeks guidance on

- Criteria for determining when to install double and triple left-turns;
- The type of phasing to be used for dual and triple left-turn lanes;
- Whether to use "Dallas" or permitted lead-lag phasing for any left-turn lanes;
- Where to begin reducing the number receiving lanes downstream of an intersection with multiple left-turn lanes.

This study uses a combination of a literature review and a nationwide survey of state practices to provide answers to these questions.

To obtain the information on current state of practice for phasing left-turns with multiple lanes, a questionnaire was sent to all the states Departments of Transportation (DOTs) by Missouri Department of Transportation (MoDOT) officials via an e-mail.

The questionnaire contained the following questions:

1. Does your agency currently have any criteria for upgrading left-turns to dual or triple left-turn lanes? If yes, please send us a copy of the criteria.
2. Under what conditions does your agency allow permissive phasing at dual and triple left-turn lanes?
3. Under what conditions does your agency allow protected + permitted phasing for dual and triple left-turn lanes?

4. Under what conditions does your agency allow "Dallas" phasing for any left-turn lanes?
5. At what distance downstream of an intersection with dual or triple left-turn lanes does your agency allow a reduction in the number of receiving lanes?

Nineteen states sent in their responses to the above questions. Based on the current practices being followed by various state DOTs and from the review of literature the following recommendations are being made.

- Capacity analysis should be used to determine the set of conditions for upgrading left-turn lanes from single to dual and dual to triple.
- If it is not feasible to perform capacity analysis due to a lack of resources, the following rules of thumb may be used for determining the point of upgrade:
  - When left-turning volume ≥ 300 vph, upgrade from single to dual left-turn lane.
  - When left-turning volume ≥ 600 vph, upgrade from dual to triple left-turn lane.
- Protected only phasing should be used for dual and triple left-turn lanes.
- "Dallas" phasing should be used instead of lead-lag protected + permissive phasing for single left-turn lanes along with R10-12a (combined R10-10L and R10-12) sign to avoid confusion to the adjacent through traffic.

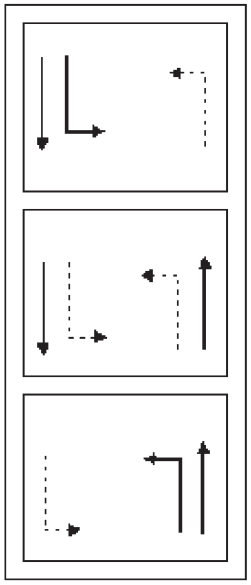
For downstream lane drop distance, consider the solution by Qiong "Joan" Shen as shown in Table 1.

Table 1: Minimum Downstream Lane Drop Distance Provided by Qiong "Joan" Shen

Green Time (s)	Percent of Heavy Vehicles						
	0%	5%	10%	15%	20%	25%	30%
	Downstream free-flow speed = 35 mph						
10	200	212	223	233	242	249	255
20	214	231	246	260	273	284	294
30	228	249	268	286	303	319	333
40	242	268	291	313	334	354	372
50	256	287	314	340	365	388	411
60	270	305	336	366	395	423	450
	Downstream free-flow speed = 45 mph						
10	200	215	229	242	254	265	275
20	214	236	256	274	291	305	318
30	228	257	283	306	327	345	362
40	242	278	310	338	364	386	404
50	256	299	337	370	400	426	447
60	270	320	364	403	437	466	490
	Downstream free-flow speed = 55 mph						
10	205	220	234	247	259	270	280
20	220	243	264	282	299	314	328
30	235	267	294	318	338	358	376
40	250	290	323	350	378	402	424
50	266	313	353	388	418	446	472
60	280	335	382	422	457	490	520

"Dallas" phasing is also known as permitted lead-lag (PLL) phasing (see Figure 1). This phasing was developed in 1978, in Dallas, Texas and hence the name "Dallas" phasing. This phasing is used to eliminate the left-turn trap, which is also known as yellow trap that occurs in lead-lag protected + permitted phasing. "Dallas" phasing eliminates the left-turn trap by introducing a permissive green for left-turning vehicles during the opposite left-turning vehicles protected phase.

Figure 1: "Dallas Phasing"



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